LAKE CITY ARMY AMMUNITION PLANT

BUILDING ONE ENERGY STUDY

EXECUTIVE SUMMARY

Corps of Engineers - Department of Defense
Olin Defense System Group
Lake City Army Ammunition Plant
Independence, Missouri 64051

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CRB Project #911737
Contract #DACA41-91-C-0062

October ~~16, 1992~~

March 17, 1993

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
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INTRODUCTION

PURPOSE OF STUDY

The purpose of this study is to audit energy consumption for Building One at the Lake City Army Ammunition Plant (LCAAP). This study identifies and evaluates various Energy Conservation Opportunities (ECO's) to determine their feasibility. Programs are developed for those ECO's determined to be feasible. This report documents the results of the energy audit and ECO analysis.

WORK COMPLETED

All work listed in the scope of work is complete and is submitted herewith for review. In brief, the work is described below:

The energy consumption audit was performed. The Building One audit includes verification of the following: HVAC system operation; HVAC equipment sizes; process system operation; process equipment sizes; architectural characteristics; facility operating methods; local weather information; historical energy records; energy sources; production data; and current construction projects.

The energy analysis results have been programmed. This analysis includes the following: computer modeling of energy-consuming systems; development of existing and projected energy consumptions; division of building into zones; identification of possible ECO's; elimination of unfeasible ECO's; calculation of ECO energy savings, simple paybacks, and savings-to-investment ratios (SIR's); and arrangement of ECO's into military funding programs.

REPORT FORMAT

Following this Executive Summary introduction, Building One is described in detail. This includes descriptions of architectural construction, facility layout, heating, ventilating, and air conditioning (HVAC) systems, process systems, and electrical systems.

Methods of calculations and assumptions are described in the following section. Existing utility consumption is graphically shown. The graphs are followed by calculations showing which systems use the different utilities.

The energy overview is followed by a discussion of this study's results. Original ECO's are listed and proposed packaging of these ECO's for military funding

programs is described. The synergistic effect of these projects on utility consumption is projected.

The Executive Summary is followed by Operational Change Recommendations. These recommendations result from one ECO studied under this project. This ECO has no capital investment costs, and only affects operations and maintenance.

Following the Operational Change Recommendations, ECO's that show a feasible simple payback during peacetime are listed and described. These discussions do not include synergistic effects of other ECO's.

Those ECO's that show a feasible simple payback only during full mobilization follow the Peacetime Energy Conservation Opportunities. These ECO's are only recommended if LCAAP is selected for full mobilization.

Full mobilization ECO's are followed by discussions of unfeasible ECO's. These are ECO's that were studied in depth for this project, but showed an unfeasible simple payback.

For each ECO discussed, an introduction states the intent of the ECO. The introduction may also include pertinent general information. A description of the existing system affected follows the introduction. Next, proposed modifications for the system are listed in detail. References to relevant tables, graphs, and sketches are made in the body of the report. The body concludes with a summary of proposed modifications, their costs, simple paybacks, and SIR's for peacetime and full mobilization scenarios. Supporting calculations, tables, and life cycle cost analysis worksheets follow the summary.

Unfeasible ECO's are followed by a discussion on ECO's that were considered but not studied. This list includes ECO's mentioned in the Scope of Work and additional ECO's that were considered but not analyzed. Justification for dismissal is provided for each ECO.

The final section of this volume is a list of references for this study.

This volume of the report is one of five volumes for this study. The entire report includes the following volumes: Executive Summary, Final Submittal, Military Funding Programming Documentation, Appendix: Volume I, and Appendix: Volume II.

All calculations for this report can be found in the two volumes of the Appendix.

BUILDING ONE DESCRIPTION

GENERAL DESCRIPTION

Lake City Army Ammunition Plant (LCAAP) is located in Independence, Missouri approximately eight miles east of Kansas City, Missouri. The 442-building plant occupies approximately 3,900 acres. The purpose of the plant is to manufacture and test small arms ammunition. The plant was dedicated in November of 1941 and operated continuously until 1945. The plant operated intermittently from then until 1954 when it became a permanent Department of the Army installation. In 1963 it was officially named the Lake City Army Ammunitions Plant.

ARCHITECTURAL DESCRIPTION

Building One houses the manufacturing and packaging process for 5.56mm small arms ammunition. In the mid 70's, new Small Caliber Ammunitions Manufacturing Process (SCAMP) equipment was installed. In 1982 an energy study was performed on Building One. The study resulted in many architectural energy efficiency projects. Projects currently being designed or constructed include the following: renovate the mezzanine offices; install humidity and temperature control for the electronics lab; replace casing line DC drive motors with AC motors; and expand the capacity of the compressed air system.

Building One has a floor area of 352,129 gross square feet, an exposed window area of 3,633 gross square feet, and 3,023 square feet of door area. Building One is currently occupied by as many as 328 employees daily.

The west end of the building is one-story construction. The center two-thirds of the building is high-bay with a metal grate and concrete mezzanine. The east end of the building is two-story support areas. Throughout the facility, the roof is separated from the walls by approximately ten feet of windows. Most of these windows were covered with insulated panels in 1984. The roof is made of five-ply built-up roofing with two inch thick, rigid mineral fiberboard insulation. The roof has a U-factor of 0.11. Most windows are double-pane glass, but there are some single-pane office windows. Doors are swinging, double-leaf, single-leaf, and overhead. Most of the doors are in good condition and have good weather-stripping. The loading dock doors lack good seals. Portions of the plant have operable louvered openings for outside air ventilation. These openings are covered in the winter to prevent leakage. The majority of the walls are 8" concrete masonry units (CMU) and 4" common brick construction.

For the purposes of this study, Building One is divided into sixteen separate zones. These zones are: Cafeteria, Locker Rooms, Annealing, Case Manufacturing, Storage, Tracer Charging, Priming, Load and Assemble, Inspection Wings, Offices, Bullet Manufacturing, Mechanical Room, Packaging, Maintenance Shops, and Product Storage and Shipping. These zones are illustrated in *Figure I.01*.

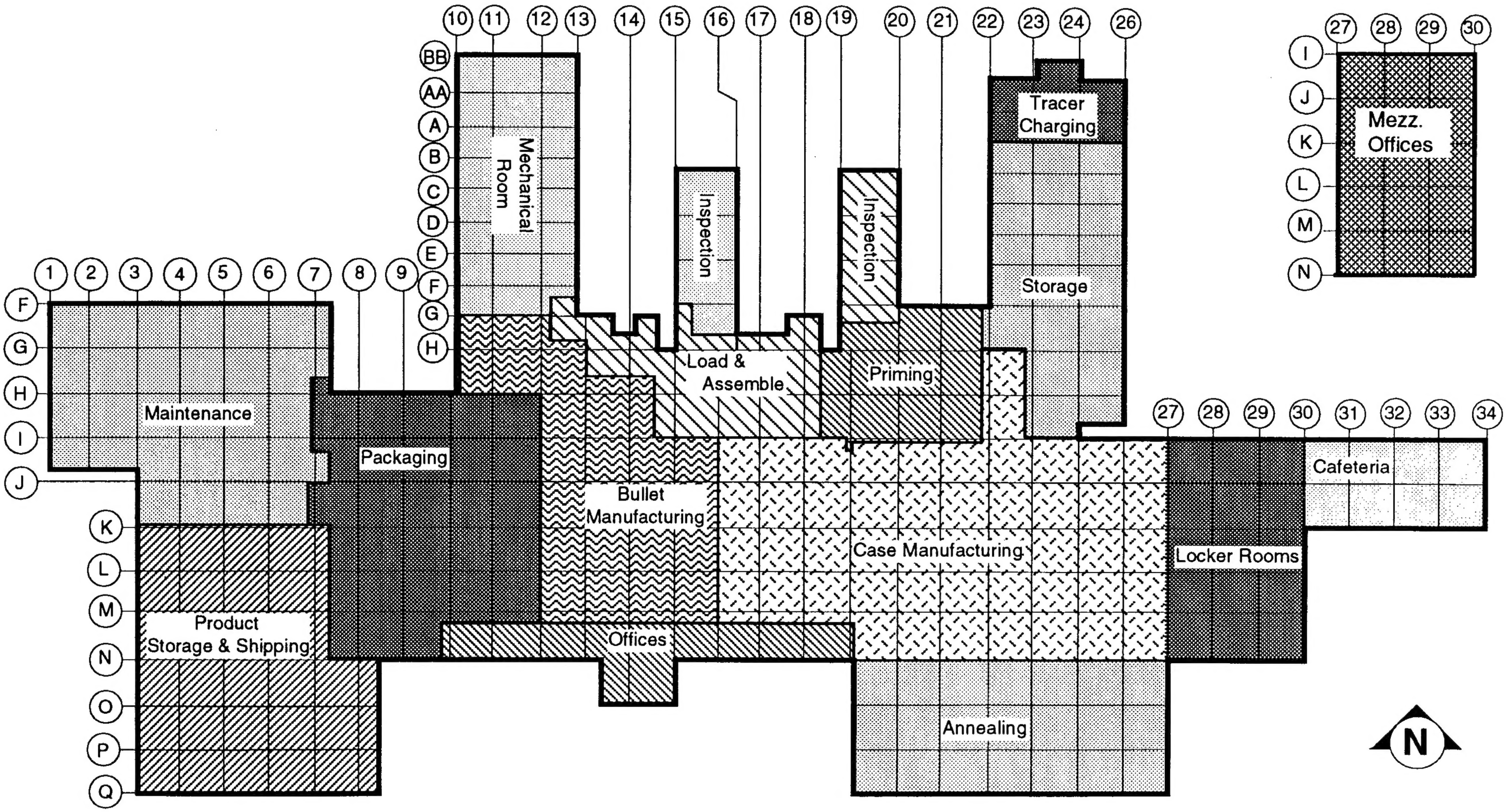


Figure I.01 Building One Architectural Zones
No Scale

HVAC SYSTEMS

Building One contains a variety of HVAC systems, the most common being heating-only and ventilating-only units. Isolated areas have year round conditioning as described in the zone discussions below. There is no building wide energy management system, however, a small stand alone system controls the start-stop function of some units. This system is described in more detail later in this section.

MAINTENANCE SHOPS AND PRODUCT STORAGE AND SHIPPING

The Maintenance and Shipping area in the west end of the building is heated by steam heating and ventilating units (HV's) and steam propeller unit heaters (UH's). The HV units are located around the inside perimeter of the area, and the UH's are located throughout the area. Many of the HV's are old and need repair. Many of the HV outside air intakes have been manually blocked closed.

Summer ventilation is provided by roof-mounted, manually-switched exhaust fans (EF's). Sources of exhaust in this zone include a paint spray booth, a furnace hood, and a local welding snorkel.

Contained within the Maintenance and Shipping area are small air conditioned offices which are cooled with packaged through the wall units that reject heat to the surrounding area. Another office has a packaged wall unit that rejects heat to outside air. One office is cooled by a DX unit with a single pass, water-cooled condenser. The water from the condenser is discharged to a floor. Another office has a packaged wall unit that rejects heat to outside air. The offices are heated by steam radiators and steam propeller UH's.

drain?

ANNEALING, MECHANICAL ROOM, AND LOCKER ROOMS

Annealing, Mechanical Room, and Locker Rooms zones have similar HVAC systems. A typical system consists of heating and ventilating air handling units (AHU's). These AHU's contain filters and a steam heating coil. The AHU's operate in the summer to provide ventilation and circulation. Minimum exhaust for the locker rooms is provided. Free-standing fans circulate air in the annealing area.

BULLET MANUFACTURING, CASE MANUFACTURING, AND PACKAGING

The Bullet Manufacturing, Case Manufacturing, and Packaging areas have similar HVAC systems. A typical system consists of heating and ventilating air

handling units (AHU's) located on the mezzanine. These AHU's contain filters and a steam heating coil. The AHU's operate in the summer solely for ventilation and circulation purposes.

Summer ventilation in these areas is provided by roof-mounted manually-switched EF's. Process exhaust fans used in the Case Manufacturing area exhaust approximately 10% of the total air supplied to these areas. Free-standing fans circulate air in these areas.

PRIMING

The AHU serving the Priming area has a steam coil for heating, and a direct expansion (DX) cooling coil. The return air system contains air washers which are not in use at this time. Plant personnel stated that these units supply 100% outside air and that the air washers are not operated due to high humidity problems. We were not able to identify any means of humidity control in this area.

LOAD AND ASSEMBLY

The AHU serving the Load and Assembly area have chilled water cooling coils and steam coils. The return air system contains air washers which are not in use at this time. Plant personnel stated that these units supply 100% outside air and that the air washers are not operated due to high humidity problems. We were not able to identify any means of humidity control in this area.

INSPECTION WINGS

The inspection wings are served by heating and ventilating units. These units are suspended near the roof of the areas they serve. They have short ductwork with diffusers that direct the air down into the occupied areas.

TRACER CHARGING

The Tracer Charging area is operated periodically throughout the year. The area is served by two 100% outside air AHU's. Each AHU has humidity control, a reheat coil, a steam heating coil, and a chilled water cooling coil. Chilled water is provided by two dedicated air cooled chillers. Relief air from the space is filtered by air washers before being exhausted to atmosphere.

CAFETERIA

The Cafeteria is served by an AHU with steam heating and chilled water cooling coils. The kitchen located adjacent to the cafeteria is not in use, and is heated

by steam propeller UH's and cooled by the same AHU that cools the cafeteria. The entrance area adjacent to the Cafeteria is heated by steam propeller UH's. These units are manually shut off in the summer.

STEAM DISTRIBUTION SYSTEM

Plant steam at 190 pounds per square inch (PSI) is produced in Building 15 and is delivered to Building One through a 10" steam main. This main extends through Building One and serves Building 7. Steam meters are located at the inlet and outlet to Building One. Pressure reducing stations in Building One reduce the steam to 90 and 10 PSI for comfort, hot water, and process use. The case manufacturing lines are served by 90 PSI steam and the condensate is piped to drain. All other steam users are piped to a condensate return system.

Condensate return piping is uninsulated and is returned to a flash tank with a 10 PSI relief valve. The 10 PSI flash steam is used for radiant heating and for preheating of the domestic hot water system. Condensate from the condensate receiver is pumped back to the boiler plant in Building 15.

Engineering personnel at Lake City Army Ammunition Plant calculate the average cost to produce 190 PSI steam is $4.75 per 1000 lbs. This number includes all steam system inefficiencies. Based on a steam cost of $4.75 per 1000 lbs. of steam at 841 BTU/lb., and a natural gas cost of $3.05/MCF, it takes 1.9 BTU's of gas to produce 1 BTU of steam. Because the Life Cycle Cost in Design (LCCID) program does not allow for a facility wide steam system (other than district steam), all steam savings were multiplied by 1.9 and were entered in the Natural Gas savings line of the LCCID program.

CHILLED WATER SYSTEMS

The chilled water system is located in the mechanical room and consists of two 120 ton screw-type chillers, three chilled water pumps, two cooling towers, and three condenser water pumps. The chilled water is supplied at 42° Fahrenheit (F). One chiller modulates to handle the entire load. The second chiller can be brought on line manually in case of primary chiller failure. This system supplies chilled water to eight air handling units. Chilled water coils are modulated using three way control valves.

Two eighty-ton packaged air-cooled chillers supply chilled water to two air handling units serving the Tracer Charging area. These chillers are dedicated to the Tracer Charging wing and operate independently from the screw chillers located in the mechanical room.

NATURAL GAS SYSTEM

Natural gas is supplied to Building One at 40 to 45 psig, A 6" gas main enters the building along the west wall of the Product Storage & Shipping area. Natural gas is presently being supplied by KPL Gas Service at a rate of $3.05 per MCF. Based on the Energy Conservation Investment Program standard of 1,031,000 BTU's per MCF, natural gas cost is $2.96/MBTU.

PROCESS SYSTEMS

INTRODUCTION

Building One houses the Small Caliber Ammunition Manufacturing Process (SCAMP), the process of manufacturing 5.56 millimeter (mm) ammunition. This process consists of the following sub-modules and systems: cup and lead receiving/preparation, case manufacturing line, bullet manufacturing line, priming line, loading and assembly line, tip identification, packaging/shipping line, conveying system, and compressed air system.

From unloading the cups off rail cars to placing completed packaged rounds on rail cars, rounds are manufactured in sub-continuous batches. The sub-modules use automatically conveyed holding bins for each batch, with the following exceptions: annealed bullet cups are manually dumped into the bullet lines through the mezzanine floor from a hand cart, and annealed casing cups are manually loaded into the conveying system on the main floor. *Figure I.02* shows a flow diagram of cartridge manufacturing.

PRODUCTION SCHEDULE

Three production shifts are currently operating in Building One. According to manufacturing engineers assigned to Building One, compressed air capacity is the production limiting factor. A compressor installation is currently being designed. Upon installation of the new compressors, all five casing lines could operate simultaneously. However, casing lines are occasionally shut down for retooling.

This study assumes that the new compressors will be installed within the next two years. In addition, this study assumes that annual peacetime production is 2500 hours and that full mobilization production is 8760 hours. Manufacturing and facilities engineers estimate that each casing line will operate approximately 80-85% of the time.

GENERAL PROCESS DESCRIPTION

Raw material casing cups are brought from a rail car into the annealing area. The cups are then washed and annealed. They are dumped into a conveyor system that distributes them to one of five case manufacturing lines. Casings from the manufacturing lines are conveyed, into the loading area or to hoppers for storage.

Raw material bullet cups are brought from a rail car into the annealing area. Some of the cups are washed and annealed. These cups are placed in carts which are delivered to the mezzanine by an electric truck and elevator. Depending on the type of bullet being manufactured, the remaining raw material cups are brought to the mezzanine by electric truck and elevator to be washed and annealed. All washed and annealed cups are then wheeled manually to a dumping station and dumped into the bullet manufacturing line. Bullets are then conveyed to a polisher, and then to the loading area, or to a hopper for storage and subsequent loading.

Bullets and casings are loaded, assembled, and primed in the north area of the building. Each of these manufacturing lines is connected to a common packaging or conveying system. After the cartridge has been completely assembled, it is conveyed to storage hoppers for subsequent packaging. In packaging, the cartridge feeds into a packaging machine. Workers assemble groups of packages into pouches and boxes. The final box is conveyed to a palletizer. The final pallet is then loaded by electric truck into a rail car.

CUP AND LEAD RECEIVING/PREPARATION

Casing cups, bullet cups, and lead pellets are unloaded from rail cars and brought into the southeast corner of Building One. Two areas of the plant are used for cup preparation. All casing cups and some bullet cups are washed and annealed near the receiving dock. The remaining bullet cups are moved by electric truck to the mezzanine to be washed and annealed by a second set of machines. Lead pellets are also moved by electric truck to the mezzanine and are cleaned and polished for insertion into the bullet lines.

In both cup preparation lines, the brass cup is dumped from a pallet or cart into a washer which uses hot water, steam, and a natural gas-fired dryer to clean the cup of all deposits from the manufacturing process. The cup is then conveyed to the annealing process where it passes through a 1200° Fahrenheit (F) natural gas-fired furnace. The cup is transferred from the annealing furnace to an acid bath and then to heated rinse water which removes annealing deposits. It is then dryed with a blower and dumped into a crate.

Natural gas, steam and electricity are the utilities used in cup and lead preparation. Natural gas is used in the annealing furnaces and the washers. Steam heats water in the pre-annealing washer and post-annealing washer. Electricity is used in the conveying system and to power other motors in the preparation lines. Energy from the hot air in the annealing furnace is recovered and transferred to the washer/ dryer.

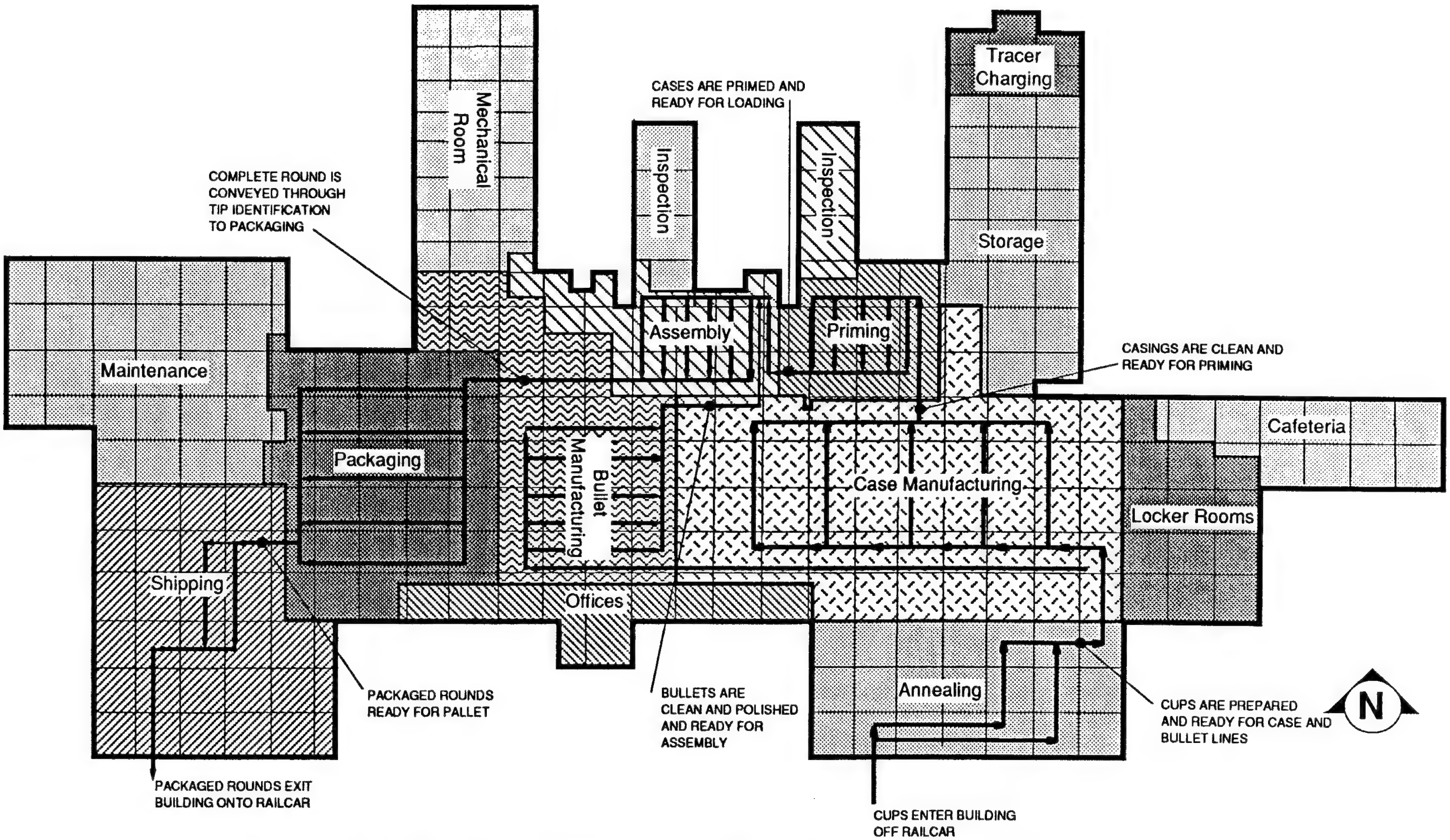


Figure I.02 - Cartridge Manufacturing Flow Diagram

No Scale

CASE PRODUCTION LINE

Casing cups are dumped into the conveying system after being annealed and washed. The cups are directed from overhead into holding bins. They are then conveyed out of the holding bin into a rotating piece of equipment that engages the cup production. Each cup is moved by a series of production chains that deliver the cup through punches and annealers along the entire case line. The cup is first punched from underneath for its first draw. The drawn cup then follows through several machines that anneal, wash, oil, draw, and trim to specifications.

A cooling system is used to cool the annealing inductance heater power supplies and the casing line drive train. Process water serves each casing line. The process water serves the drive train, and a heat exchanger for the inductance heater cooling water. Process water is cooled by a combination of cooling towers and air-cooled chillers to maintain 68°F and is pumped into a storage tank in the southwest corner of the annealing area. Cooling water is maintained at 72°F by the heat exchanger and is pumped into a holding tank.

Electricity, steam, potable water, and compressed air are the utilities used in the casing manufacturing line. Motors and annealing induction heaters consume the majority of electrical power for the line. The entire case line is driven by several large electrical motors controlled at varying speeds. The motors turn the chains, drums and conveying for the entire case line. Washers consume all of the steam and potable water used for cleaning the casing after drawing and trimming. Punch drums and blow off nozzles consume the compressed air.

BULLET LINE MANUFACTURING LINE

The bullet manufacturing line is similar to the case line. The bullet is manufactured on a single continuous line driven by large electric motors. The cup is transferred down the production line by chains and rotating drums. The cup is drawn and trimmed similar to the case sub-module line.

Electricity and compressed air are the utilities used in the bullet manufacturing line. The line consumes electricity to operate the motor and controls. The bullet line uses compressed air to operate controls and punches on the drums.

PRIMING SUB-MODULE

The casing travels from the case manufacturing line to the priming area on a conveying system. The cap and primer is installed in the casing with a production line similar to the bullet manufacturing line. A chain moves through

drums where the primer and cap is installed. The entire line is driven by motors turning the drums and chains.

Electricity and compressed air are the utilities used in the priming sub-module. The priming sub-module consumes electricity to power drive motors. Compressed air is used to operate controls and pistons on the drums.

LOADING SUB-MODULE

The loading sub-module assembles the primed casing and the bullet to complete the cartridge. A primed casing enters the line on a chain and drum system and is loaded with gunpowder. The bullet is then set on the casing and the cartridge is crimped together. The completed round then is conveyed to finish painting, packaging and shipping.

Electricity and compressed air are the utilities used in the loading sub-module. Electricity is used to turn drive motors. Compressed air is used to set and crimp the bullet on the casing.

TIP IDENTIFICATION SUB-MODULE

The tip identification sub-module coats the tips of assembled cartridges for identification purposes. The cartridge enters the painting sub-module from a conveyor and enters a series of drums which coat the tip. The round is then conveyed to the shipping area for packaging.

Electricity and compressed air are the utilities used in the tip identification sub-module. Electricity is used to power drive motors Compressed air is used to spray the paint on the cartridge.

PACKAGING AND SHIPPING

Completed rounds drop into one of several different packaging lines. The rounds are bundled into pouches or several hundred round straps and are then packed into ammunition boxes. Ammunition boxes are packed into small crates and are then conveyed to a palleting area for shipping.

Electricity and compressed air are the utilities used in packaging and shipping. The packaging lines and the palleting area use electricity for conveying and drive motors. Compressed air is used in staple guns and sewing machines, and for controlling of conveying systems.

Product Conveying

With one exception, each work piece moves through the various areas of the manufacturing process on a conveying system. Bullet cups and lead pellets are moved to the mezzanine by electric truck and elevator.

Electricity and compressed air are the utilities used for product conveying. Electricity is consumed by the motors driving the conveyor belts and cups. Compressed air operates controls that maneuver the work piece to the proper holding bins.

Compressed Air System

The compressed air plant consists of four centrifugal compressors, each producing 2450 actual cubic feet per minute (acfm) of air at 110 pounds per square inch (psi). Each air compressor is driven by a 600 horsepower (HP) electric motor. The chamber of each compressor is cooled by condenser water. The condenser water system consists of a holding tank, three pumps, and two roof-mounted cooling towers. The tower fans are turned on by an increase in condenser water temperature which indicates the operation of several compressors. ?

The compressed air from each compressor is piped into a common header. The compressed air is routed though several refrigeration dryers and filters before being piped to the users on the main floor. The compressed air is piped around the perimeter of the entire main floor. The main energy inputs to the compressed air system are electricity and potable makeup water.

The largest compressed air user on the main floor is the casing line. The air nozzles used on the washing sections of the case line consume large amounts of air to blow off the casing. The HVAC systems consume a small amount of compressed air for the controls, but not significant in comparison to the process lines.

ELECTRICAL SYSTEMS

GENERAL SYSTEM DESCRIPTION

Building One has nine service entrances totaling 21,500 kilovolt-amps (KVA). All but 4000 KVA are transformed to 277/480 volt (V) for use in the main factory. Some power is transformed to 120/208V for lighting and convenience receptacles. Air compressors in the Mechanical Wing are served by 4000 KVA transformed to 4,160V.

LIGHTING SYSTEM

Lighting in the main factory is provided by fluorescent industrial fixtures with some uplight. These fixtures have been mounted on chains or metal hooks and hang from the conduit serving the fixture. Fixtures are plugged into receptacles with a six-foot electrical cord. As part of previous energy analysis recommendations, many of the fixtures were unplugged where they were not needed. Light fixtures are operated by panelboard circuit breakers in most areas.

Lighting in office areas is provided by inexpensive fluorescent fixtures with wraparound lenses. These fixtures have been surface mounted on the ceiling and are operated by wall switches. Many of the lamps have been removed from the fixtures as part of a previous energy savings measure.

MOTORS

Building One has both alternating current (AC) and direct current (DC) motors ranging from 1/4 horsepower (HP) to 600 hp. All DC motors are equipped with variable speed drives that transform the power and provide precise control of the manufacturing lines. The most common AC motor size is 1/2 HP.

Few of the motors have efficiency ratings engraved on their nameplate. This means that these motors were installed prior to 1977, when the National Electrical Manufacturers Association (NEMA) required manufacturers to engrave efficiencies on nameplates. Several motor manufacturers confirmed that most of the existing motors are not high efficiency,

CONSUMPTION CHARGES

Lake City Army Ammunition Plant is charged for electricity on a plant-wide basis at the Kansas City Power & Light Company Primary Service-Large rate (see

Appendix). LCAAP personnel usually determine what percentage of total facility consumption results from Building One. Based on the electrical cost for Building One over a one year period, average electrical cost is \$0.0565 per kilowatt-hour (KWH), or \$16.41 per MBTU.

METHODS AND ASSUMPTIONS

INTRODUCTION

This section discusses the methods used in calculating energy savings and states assumptions made that relate to most calculations.

TEMPERATURE RELATED CALCULATIONS

Temperature-related calculations were made using the bin method of analysis. The bin analysis method separates all the hours of the year into temperature bins of 5° Fahrenheit (F). Calculations have been divided into bins, ranging from 104/100°F to -6/-10°F. The median temperature from each bin was used in each calculation. The number of hours in each bin was taken from "Engineering Weather Data" [2], (AFM 88-29) for Richards-Gebaur AFB. Bin temperature ranges and associated hours are shown in *Calc I.01.* This method is fully documented in Chapter 28 of the 1989 ASHRAE Handbook of Fundamentals [6].

PEACETIME AND FULL MOBILIZATION CALCULATIONS

Peacetime and full mobilization calculations were segregated due to the different number of production hours in a year with which each is associated. Peacetime production was considered to be fifty hours a week, fifty weeks in a year, for a total of 2,500 hours per year. Full mobilization production was considered to be twenty-four hours a day, 365 days per year for a total of 8,760 hours per year.

Weather data in "Engineering Weather Data" is divided into three, eight hour time periods: 12 am to 8 am, 8 am to 4 pm, and 4 pm to 12 am. The number of hours in each peacetime bin was determined by taking the ratio of 2500 hours to the total bin hours from 8 am to 4 pm.

HVAC COOLING CALCULATIONS

A computer simulation program, "ELITE" HVAC Loads Program, was used to determine cooling skin loads. A program printout which shows the loads is in the appendix.

Total cooling energy consumption includes energy consumed for direct expansion (DX) cooling and chilled water cooling. The ventilation air used is the total supply air from 100% outside air units and 10% of the total supply air

for all other units. The space temperature used is 78°F. *Calcs I.02 thru I.04* show chilled water cooling energy consumption. *Calcs. I.05 thru I.07* show DX cooling energy consumption.

HVAC HEATING CALCULATIONS

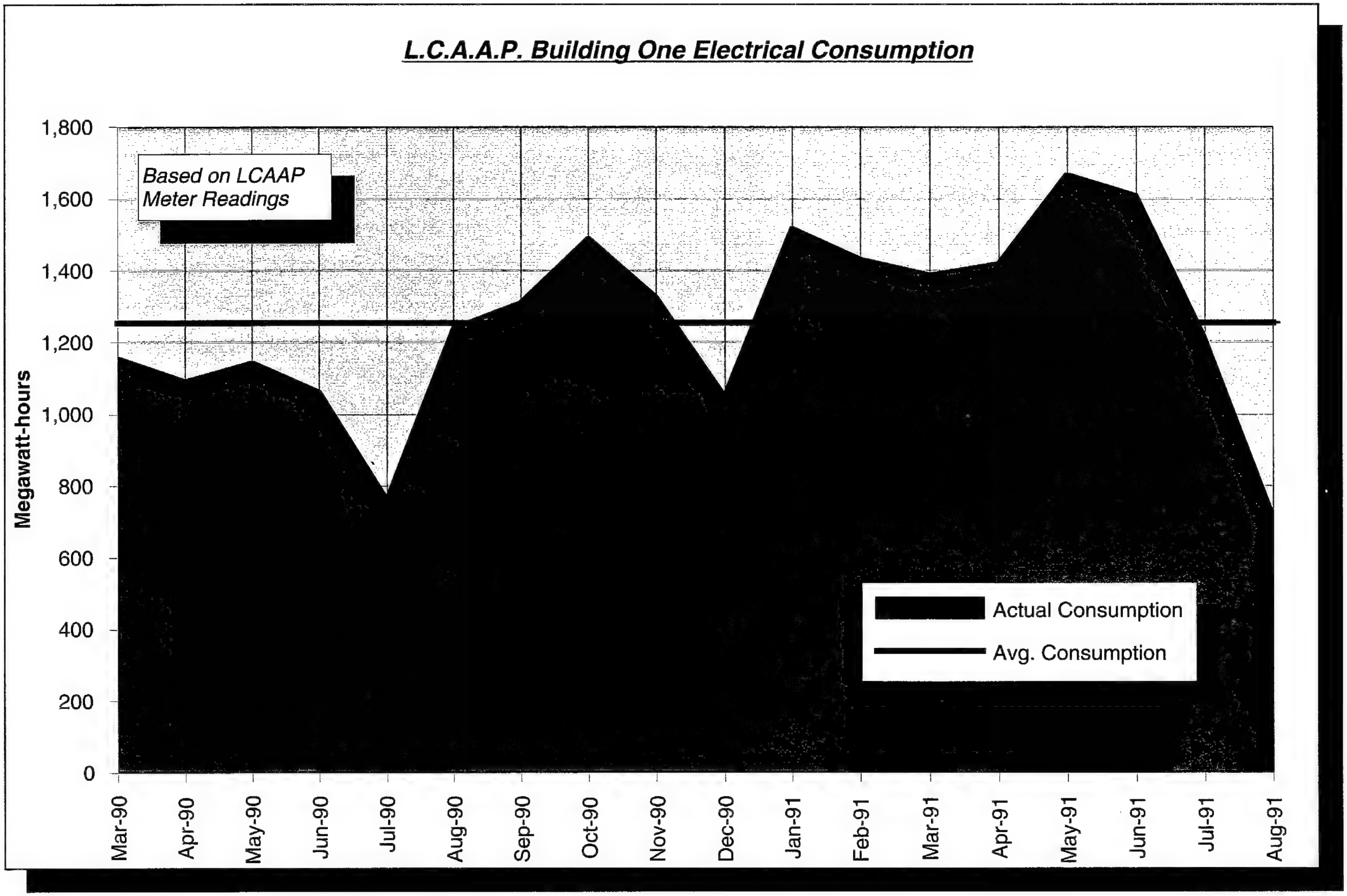
Total heating energy consumption includes heating skin loads, infiltration load, and ventilation air heating load. Thermal transmission factors (U-factors) for the building envelope were used in calculating skin heating loads. A temperature set point of 68 °F was used. An average wind speed of 9 miles per hour was used to calculate infiltration. The ventilation air used is the total supply air from 100% outside air units and 10% of the total supply air for all other units.

Calcs I.08 thru I.10 show total heating energy consumption.

ENERGY CONSUMPTION

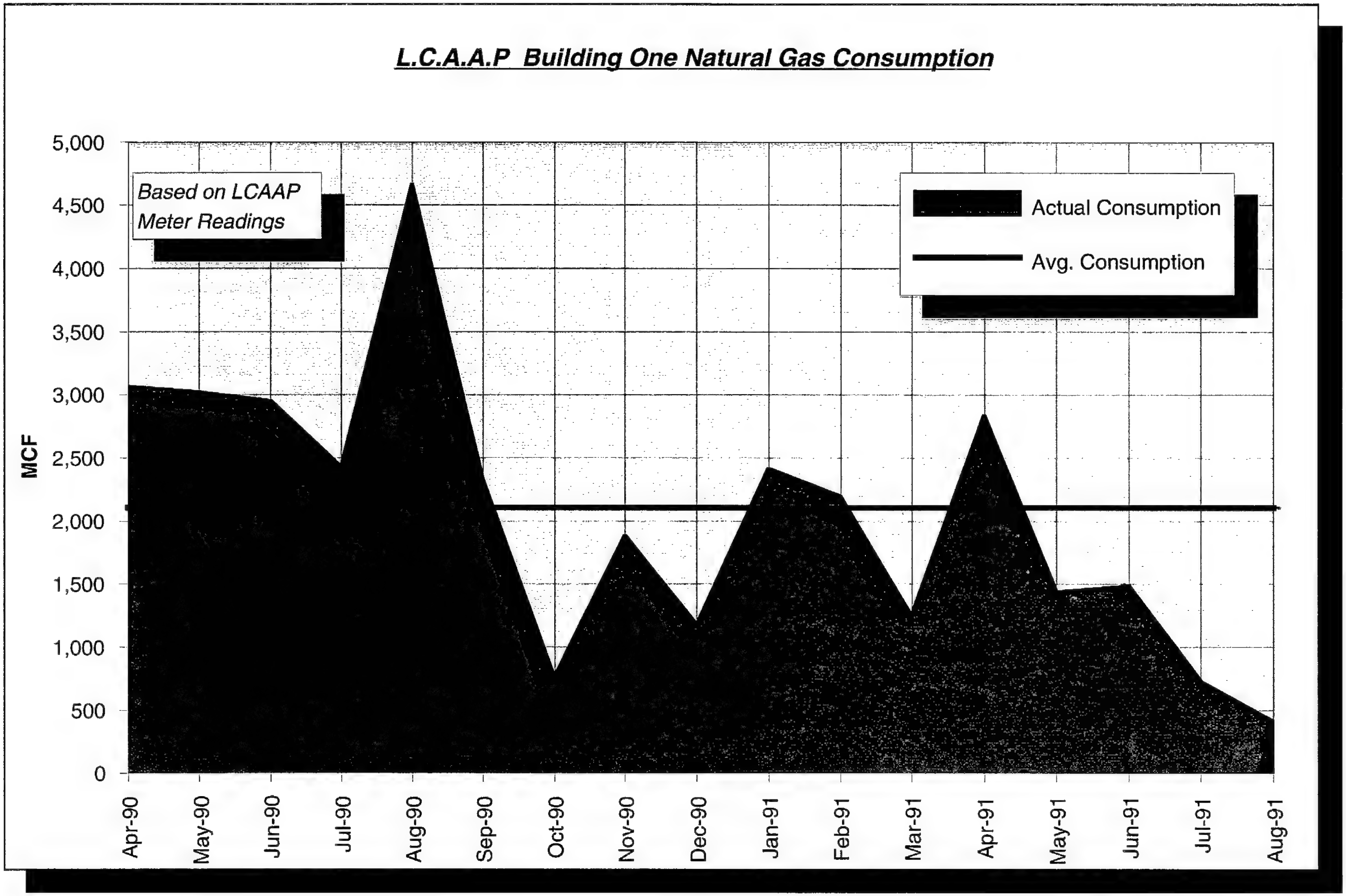
Olin Corporation provided metered electricity, gas, and steam consumptions for the period from March 1990 to August 1991. *Graphs I.01 thru I.03* show actual and average energy consumption and *Graph I.04* shows actual and average production for this eighteen month period, based on the data Olin provided. Summaries of calculated energy consumption by utility and by system are shown in *Tables I.01 and I.02.*

A comparison of calculated versus actual metered energy consumption for gas, electricity and steam is given in *Table I.03.* In all cases the percent difference between calculated and actual consumption is less than 15%.

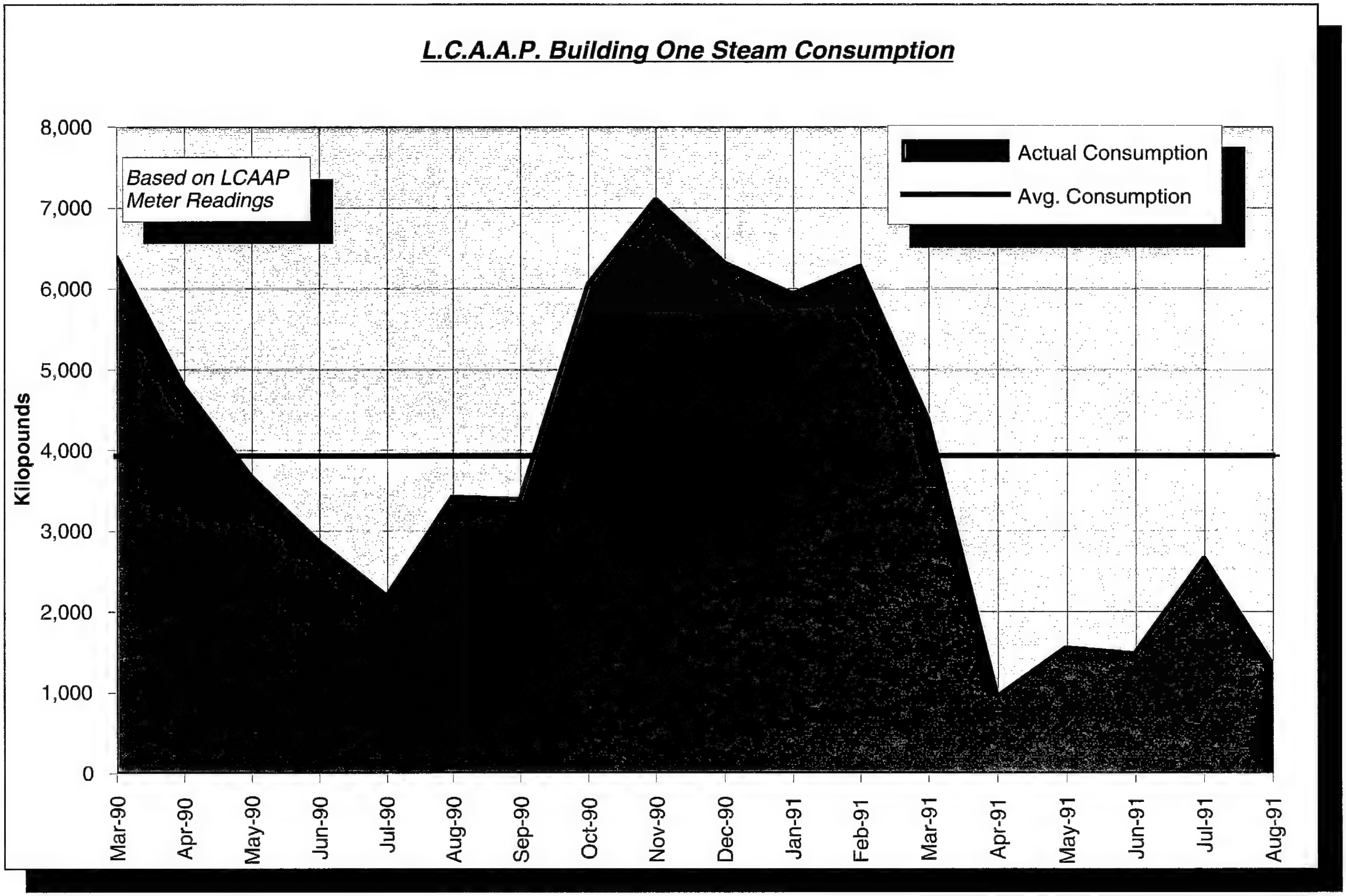


L.C.A.A.P. Building One Electrical Consumption
Based on LCAAP Meter Readings
Megawatt-hours
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Mar-90
Apr-90
May-90
Jun-90
Jul-90
Aug-90
Sep-90
Oct-90
Nov-90
Dec-90
Jan-91
Feb-91
Mar-91
Apr-91
May-91
Jun-91
Jul-91
Aug-91
Actual Consumption
Avg. Consumption

Graph I.01

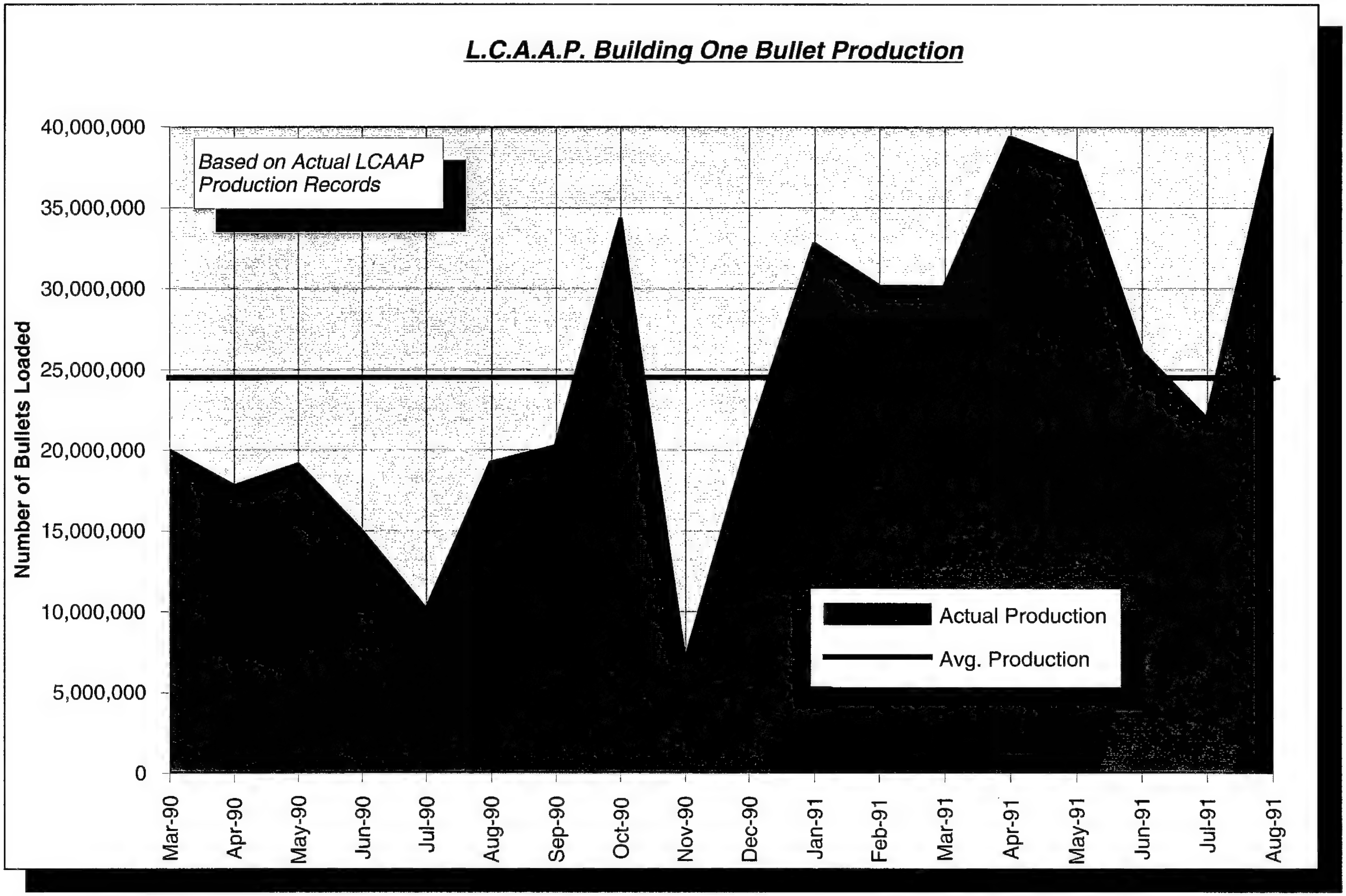

L.C.A.A.P Building One Natural Gas Consumption
MCF
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Based on LCAAP
Meter Readings
Actual Consumption
Avg. Consumption
Apr-90
May-90
Jun-90
Jul-90
Aug-90
Sep-90
Oct-90
Nov-90
Dec-90
Jan-91
Feb-91
Mar-91
Apr-91
May-91
Jun-91
Jul-91
Aug-91

Graph I.02



L.C.A.A.P. Building One Steam Consumption
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Kilopounds
Based on LCAAP Meter Readings
Actual Consumption
Avg. Consumption
Mar-90
Apr-90
May-90
Jun-90
Jul-90
Aug-90
Sep-90
Oct-90
Nov-90
Dec-90
Jan-91
Feb-91
Mar-91
Apr-91
May-91
Jun-91
Jul-91
Aug-91

Graph I.03



L.C.A.A.P. Building One Bullet Production
Based on Actual LCAAP Production Records
Number of Bullets Loaded
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Mar-90
Apr-90
May-90
Jun-90
Jul-90
Aug-90
Sep-90
Oct-90
Nov-90
Dec-90
Jan-91
Feb-91
Mar-91
Apr-91
May-91
Jun-91
Jul-91
Aug-91
Actual Production
Avg. Production

Graph I.04

Corp of Engineers - Department of Defense
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TOTAL YEARLY ENERGY CONSUMPTION - PEACETIME SUMMARY

	Heating Load (MBTU)	190 PSI Steam (LBS.)	Electricity (KWH)	Natural Gas (MCF)

NON-PRODUCTION HOURS

HVAC				
HEATING	25,275	30,053,032	694,010	
COOLING				
DX			449,353	
CHW			184,475	
HVAC TOTAL	**25,275**	**30,053,032**	**1,327,838**	

PROCESS				
PROCESS HOT WATER		0		
PROCESS STEAM		0		
PROCESS TOTAL		**0**	**0**	**0**

PRODUCTION HOURS

HVAC				
HEATING	8,367	9,948,395	277,642	
COOLING				
DX			239,426	
CHW			172,119	
HVAC TOTAL	**8,367**	**9,948,395**	**689,187**	

STEAM PIPING				
HEAT LOSS		2,318,000		

PROCESS				
PROCESS HOT WATER	42	49,941		
PROCESS STEAM		14,500,000		
PROCESS TOTAL		**14,549,941**	**13,400,000**	**30,219**

OTHER CONSUMERS				
DOMESTIC HOT WATER	11	12,485		
LIGHTING			953,331	

TOTAL CONSUMPTION	***33,641***	***56,881,853***	***16,370,356***	***30,219***

Table I.01

Corp of Engineers - Department of Defense
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TOTAL YEARLY ENERGY CONSUMPTION - FULL MOBILIZATION SUMMARY

	Heating Load (MBTU)	190 PSI Steam (LBS.)	Electricity (KWH)	Natural Gas (MCF)
HVAC				
HEATING	30,360	36,099,524	971,651	
COOLING				
DX			712,686	
CHW			470,639	
HVAC TOTAL	**30,360**	**36,099,524**	**2,154,976**	
STEAM PIPING				
HEAT LOSS		2,318,000		
PROCESS				
PROCESS HOT WATER	126	149,822		
PROCESS STEAM		50,808,000		
PROCESS TOTAL		**50,957,822**	**91,202,112**	**245,751**
OTHER CONSUMERS				
LIGHTING			3,198,090	
DOMESTIC HOT WATER	32	37,455		
ENERGY TOTALS	**30,517**	**89,412,801**	**96,555,178**	**245,751**

Table I.02

Corp of Engineers - Department of Defense
Lake City Army Ammunition Plant Building One Energy Study
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Comparison of Calculated and Metered Energy Consumption

UTILITY	ACTUAL	CALCULATED	% DIFFERENCE
ELECTRICITY - KWH	14,576,409	16,370,356	12.31%
STEAM - LBS.	58,399,000	56,881,853	-2.60%
NATURAL GAS - MCF	29,784	30,219	1.46%

Table I.03

PROJECT RESULTS

In the Interim Submittal of this report, thirty-five Energy Conservation Opportunities (ECO's) were identified:

ECO-A1	Install Loading Dock Seals
ECO-A2	Install Poly-Strip Curtains on Dock Doors
ECO-A3	Insulate Air-Conditioned Offices
ECO-A4	Improve Facility Layout and Space Utilization
ECO-E1	Install Higher Efficiency Lighting
ECO-E2	Install Lighting Controls
ECO-E3	Install High Efficiency Motors
ECO-M1	Modify and Repair Night Setback Controls
ECO-M2	Expand Existing Energy Management System
ECO-M3	Replace Pneumatic Control With EMCS
ECO-M4	Reduce Building Ventilation Air
ECO-M5	Install Radiant Heating System
ECO-M6	Install Air Destratification Units
ECO-M7	Install Dry Bulb Economizer Controls
ECO-M8	Install Summer Boiler
ECO-M9	Insulate Steam Piping
ECO-M10	Insulate Condensate Return Piping
ECO-M11	Isolate Comfort Steam
ECO-M12	Install Propeller Unit Heater Controls (Cycle Supply Fan & Steam Valve Simultaneously)
ECO-M13	Install Propeller Unit Heater Controls (Modulate Steam Valve While Running Fan Continuously)
ECO-M14	Modify Chilled Water Distribution System
ECO-M15	Install Centrifugal Chiller and Replace Direct Expansion Coils
ECO-M16	Reset Chilled Water Temperature
ECO-M17	Reset Condenser Water Temperature
ECO-P1	Replace Existing Centrifugal Compressors (Natural Gas Reciprocating)
ECO-P2	Replace Existing Centrifugal Compressors (Natural Gas Rotary Screw)
ECO-P3	Replace Existing Blowoff Nozzles
ECO-P4	Install Motorized Valves In Casing Line Compressed Air Supply
ECO-P5	Install Compressor Inlet Guide Vanes
ECO-P6	Install Cogeneration Package
ECO-P7	Condenser Water Reset Controls

ECO-P8	Recover Heat From Casing Line Cooling Water
ECO-P9	Recover Heat From Compressor Cooling Water
ECO-P10	Replace Air Compressor Cooling Towers
ECO-P11	Replace Case Sub-Module Cooling Towers

These ECO's had simple payback values ranging from 0.02 to 377 years and savings-to-investment ratios (SIR's) ranging from 0.04 to infinity. At the recommendation of the reviewers, eighteen ECO's that have simple paybacks greater than eight years have been eliminated for programming purposes. ECO-M11 has been changed to an Operation Change Recommendation because it requires no capital investment. *Table I.04* shows the ECO's that showed a feasible payback, and includes construction costs, energy consumption savings, simple payback and SIR. The ECO's are grouped into those that pay back in peacetime and those that pay back in full mobilization. ECO's are ranked by SIR.

The sixteen remaining ECO's have been divided into ten groups. Each group has similar characteristics, and fits into one of the ten economic life categories listed in the Energy Conservation Investment Program (ECIP) Guidance document. Depending on total construction costs, simple payback, and SIR, each group of ECO's qualifies for one of three different military funding programs. These programs are described briefly below.

The Quick Return on Investment Program (QRIP) is for projects that have a total cost of $100,000 or less, and a simple payback period of two years or less. One group of ECO's met these qualifications.

The Energy Conservation Investment Program (ECIP) is for projects that have a construction cost estimate greater than $200,000, SIR greater than one, and a simple payback of eight years of less. Three groups of ECO's met these qualifications.

The Energy Conservation and Management Program is for projects that meet all ECIP qualifications except for the $200,000 construction cost. Six groups of ECO's met these qualifications.

The ten projects and associated costs, energy savings, SIR's, and simple paybacks are listed in *Table I.05*. Please note that ECIP-P1: Replace Compressors with Natural Gas Rotary Screw Compressors, ECIP-P2: Replace Compressors with Natural Gas Reciprocating Compressors, and ECAM-P1: Install Heat Recovery Systems are only recommended during full mobilization. These projects show acceptable paybacks and SIR's only during full mobilization.

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Energy Conservation Opportunity Summary Sheet

ECO #	ECO Title	Construction Costs	Values in Peacetime			
			Electrical MBTU/yr	Natural Gas MBTU/yr	SIR	Simple Payback
M4	Reduce Building Ventilation Air	$2,501	0	2,787	44.0	0.3
P3	Replace Existing Blowoff Nozzles	$52,422	5,489	0	25.9	0.6
P4	Install Motorized Valves In Casing Line Compressed Air Supply	$15,076	833	0	13.7	1.1
M1	Modify and Repair Night Setback Controls	$11,618	0	3,013	10.2	1.3
M2	Expand Existing Energy Management System	$88,888	261	15,757	7.5	1.7
M9	Insulate Steam Piping	$6,127	0	688	7.0	3.0
A2	Install Poly-Strip Curtains on Dock Doors	$101,443	0	5,860	3.6	5.9
E1	Install Higher Efficiency Lighting	$10,355	290	0	3.3	4.5
P11	Replace Case Sub-Module Cooling Towers	$56,296	729	0	3.2	4.7
M3	Replace Pneumatic Control With EMCS	$495,709	261	15,757	2.7	4.4
E3	Install High Efficiency Motors	$100,218	890	0	2.2	6.9
M7	Install Dry Bulb Economizer Controls	$27,270	261	0	1.7	6.5

ECO #	ECO Title	Construction Costs	Values in Full Mobilization			
			Electrical MBTU/yr	Natural Gas MBTU/yr	SIR	Simple Payback
P8	Recover Heat From Casing Line Cooling Water	$110,598	0	12,356	6.9	3.0
P9	Recover Heat From Compressor Cooling Water	$27,956	0	1,791	4.0	5.3
P2	Replace Existing Centrifugal Compressors (Natural Gas Rotary Screw)	$1,750,116	57,429	-148,154	2.8	3.5
P1	Replace Existing Centrifugal Compressors (Natural Gas Reciprocating)	$2,880,785	56,706	-130,450	2.1	5.3

Note: Summary of ECO's not making this list are described elsewhere.

Table I.04

Corp of Engineers - Department of Defense
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Programming Documents Summary Sheet

Program #	Program Title	Total Requested	Savings			SIR	Simple Payback
			Electrical MBTU/yr	Natural Gas MBTU/yr	Maintenance $/yr		
QRIP-P1	Valve and Blowoff Nozzles Modification	$67,500	5,775	0	$0	21.1	0.7
ECIP-M1	Insulate Piping and Replace Existing EMCS	$501,800	261	16,445	$62,550	2.7	4.3
ECIP-P1	Replace Compressors with Natural Gas Rotary Screw Compressors	$1,750,100	57,429	-148,154	$0	2.8	3.5
ECIP-P2	Replace Compressors with Natural Gas Reciprocating Compressors	$2,880,800	56,706	-130,450	$0	2.1	5.3
ECAM-M1	Insulate Piping and Expand Existing EMCS	$95,000	261	16,445	$0	11.4	1.8
ECAM-M2	Insulate Piping and Isolate Comfort Steam	$6,100	0	688	$0	7.0	3.0
ECAM-M3	Replace Cooling Towers & Adjust Outside Air Dampers	$58,800	729	2,787	$0	4.1	2.9
ECAM-A1	Install Poly-strip Curtains on Dock Doors	$115,600	0	5,860	$0	3.6	5.9
ECAM-E1	Motor and Lighting Modifications	$110,300	985	0	$735	2.3	6.5
ECAM-P1	Install Heat Recovery Systems	$138,600	0	-8,294	$0	6.3	3.3

Note: Shaded programs are recommended only during full mobilization.

Table I.05

Programming documents for each project can be found in the Military Funding Programming Documents volume. Actual implementation of these projects will depend on projected plant production and Federal funding schedules.

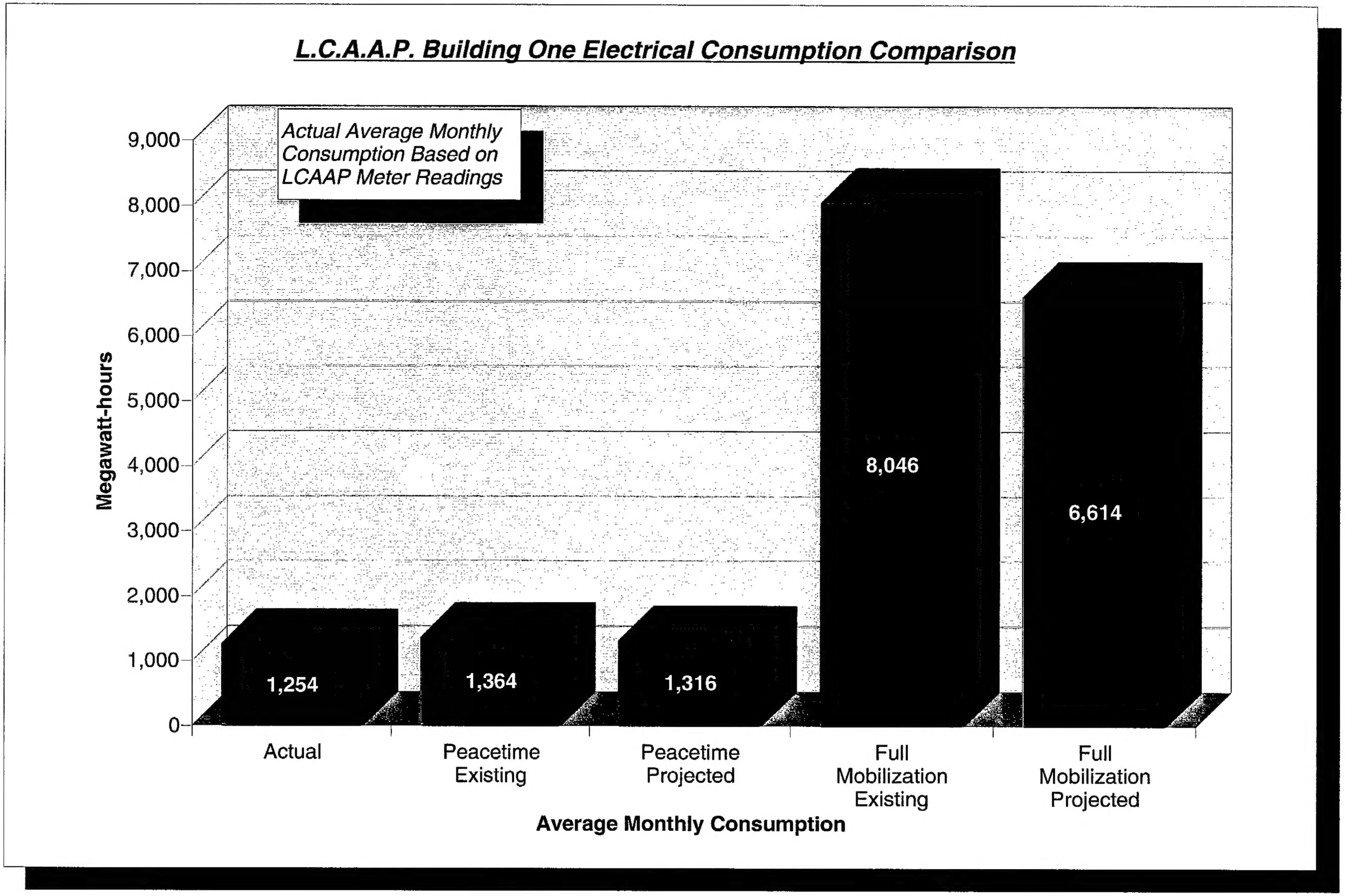
OVERALL EFFECT

In determining the construction costs, energy conserved, simple paybacks, and savings-to-investment ratios, the effect of each ECO on other ECO's within the same package were determined.

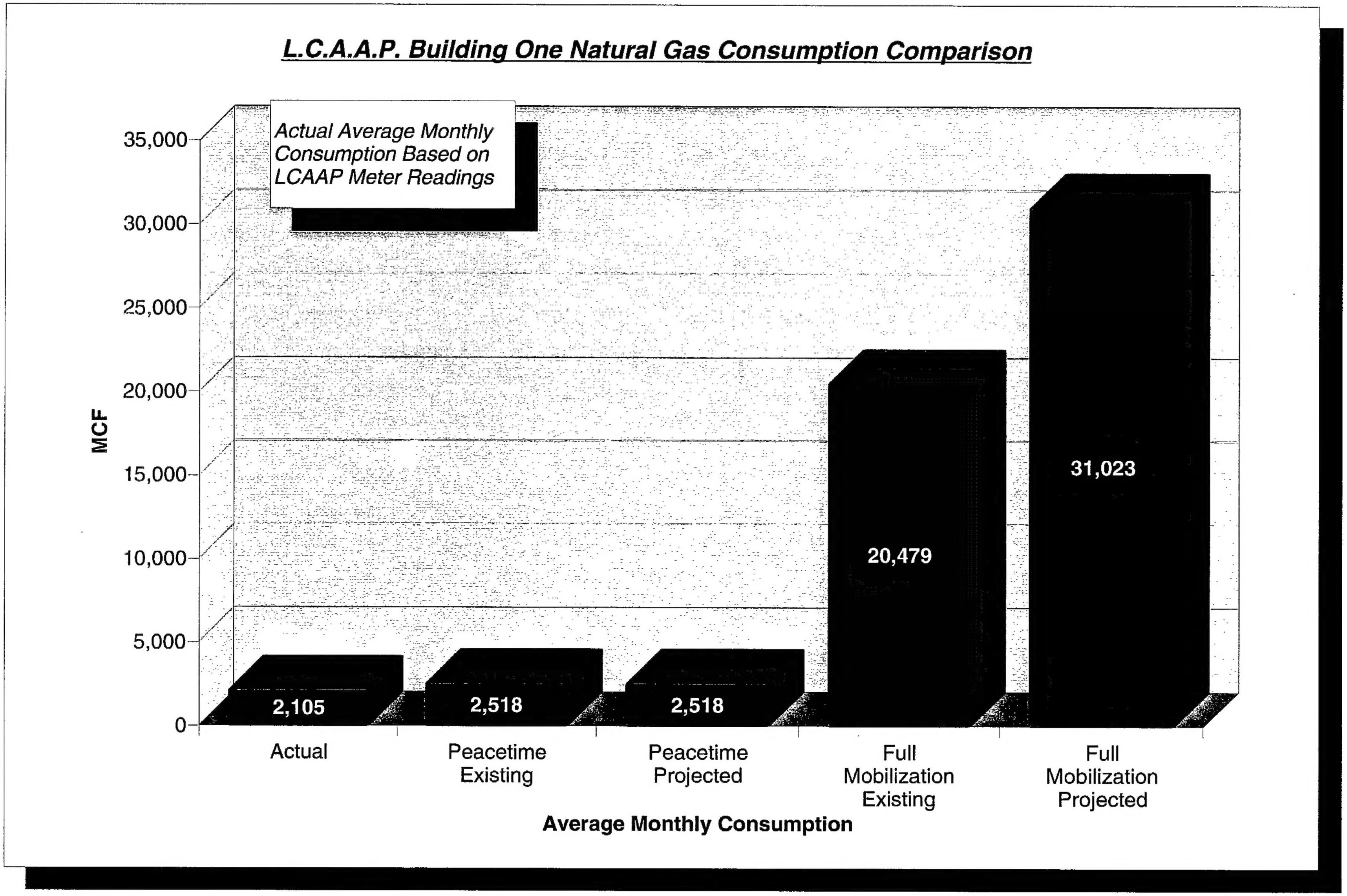
Graphs I.05 thru I.07 compare existing and projected consumption for each utility. In each graph, the following definition apply: *Actual* refers to average monthly consumption based on LCAAP meter readings; *Peacetime Existing* refers to calculated consumption during peacetime; *Peacetime Projected* refers to projected consumption based on calculated Peacetime consumptions; *Full Mobilization Existing* refers to calculated consumption during full mobilization; *Full Mobilization Projected* refers to projected consumption based on calculated Full Mobilization consumptions.

If all proposed peacetime projects are implemented, electrical consumption will be reduced by approximately 3.5% and steam consumption will be reduced by approximately 32%. Natural gas consumption will remain unchanged. The total construction cost for these programs is $786,500, resulting in $169,200 of energy savings, and a simple payback of 4.7 years.

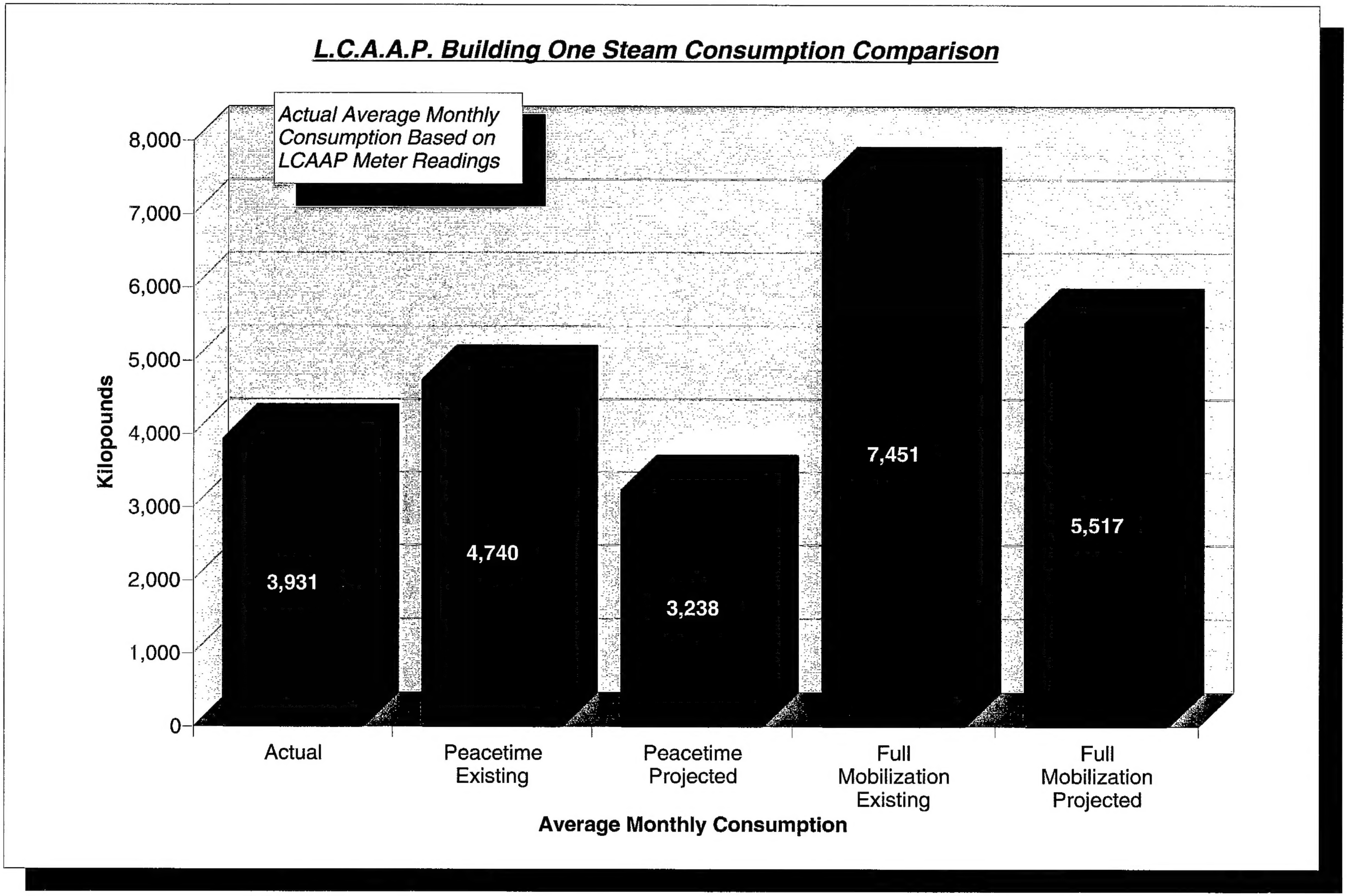
If all proposed peacetime and full mobilization projects are implemented, electrical consumption will decrease by approximately 18%, natural gas consumption will increase by approximately 52%, and steam consumption will decrease by approximately 26%. The total construction cost for these programs is $3,805,900, resulting in $763,800 of energy savings, and a simple payback of 5.0 years.


L.C.A.A.P. Building One Electrical Consumption Comparison
Actual Average Monthly Consumption Based on LCAAP Meter Readings
Megawatt-hours
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1,254
1,364
1,316
8,046
6,614
Actual
Peacetime Existing
Peacetime Projected
Full Mobilization Existing
Full Mobilization Projected
Average Monthly Consumption

Graph I.05


L.C.A.A.P. Building One Natural Gas Consumption Comparison
Actual Average Monthly Consumption Based on LCAAP Meter Readings
MCF
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2,105
2,518
2,518
20,479
31,023
Actual
Peacetime Existing
Peacetime Projected
Full Mobilization Existing
Full Mobilization Projected
Average Monthly Consumption

Graph I.06



L.C.A.A.P. Building One Steam Consumption Comparison
Actual Average Monthly Consumption Based on LCAAP Meter Readings
Kilopounds
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
3,931
4,740
3,238
7,451
5,517
Actual
Peacetime Existing
Peacetime Projected
Full Mobilization Existing
Full Mobilization Projected
Average Monthly Consumption

Graph I.07